CTS: 60-31,421

JPRS: 3580

13 July 1960

THE HUMAN BRAIN AND CYBERNETICS

— USSR —

by Yu. Frolov

Distributed by:

OFFICE OF TECHNICAL SERVICES
DEPARTMENT OF COMMERCE
WASHINGTON 25, D. C.

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N. Y.

FOREWORD

This publication was prepared under contract by the UNITED STATES JOINT PUBLICATIONS RESEARCH SERVICE, a federal government organization established to service the translation and research needs of the various government departments.

JPRS: 3580
CSO: 3919-D

THE HUMAN BRAIN AND CYBERNETICS

- USSR -

[Following is a translation of an article by Yu. Frolov in the Russian-language periodical Moskva (Moscow), Moscow, No. 3, March 1960, pages 178-182.]

Since time immemorial there has been a kind of competition going on between man's genius in design and the machines he creates. The more powerful, rapid, and accurate the machine, the more intelligent and trained man must be.

Inventors are rarely sutisfied with what they create; there is no limit to their attempts. When designing the implements of labor, they try to create complexes that can fully replace human labor; in so doing they frequently look for prototypes (models) for their offspring in animate nature. An excavator, for instance, suggests the huge hand of a man, a kind of continuation of his body; the sirfoils of an aircraft, the wings and tail of a bird; a caterpillar tractor, the movement of larva of a giant insect.

Until now, mechanization has increased only the physical strength of man and the sensitivity of his organs. By taming steam and electricity, scientists and engineers have strengthened man's nuscles; by creating microscopes and telescopes, they have made his eyes keener; by designing motor vehicles and aircraft, they have quickened his feet.

In our time we are faced with the problem of essentially lightening mental labor, the labor of scientists and design engineers themselves, the creators of machines, the organizers of production.

Several years ago a new word, a new concept, entered science and our daily life—cybernetics. "Kybernos" in Greek means a steering wheel, or control in general. The founders of cybernetics affirm that it is the science of communication and control, of communication both in inanimate nature and in animate organisms, since in both cases we mean the control of various organs on the basis of information received vrom without, and the processing of this information.

At first cybernetics was a field of communications close to telephony, telegraphy, remote control. The simplest automatic telephone connects one with any unengaged subscriber of the network, if one drops in the slot a 15-kopeck piece, which the machine itself weighs before establishing contact. If the weight of the coin is less than it should be, the machine rejects it. And although the automatic telephone does not include the ideas of cybernetics, we still find in it a very important characteristic—so-called feedback or reverse signalization of the utility of the act being done, the presence of which feedback permits the mechanism of the machine to correctly adjust to the necessary situation.

Similar feedback, comprising the basis of self-regulation, is found in more perfect automatic machines: room-cooling refrigerators with a device to maintain a given temperature; automatic pilots installed in

aircraft and in other self-regulating machines.

B ased on automation, cybernetics is an extension of it. The cyberneticist-designers have built apparatuses which, like a live telephone operator, give a connection to whoever at the moment needs it most, refusing a connection to those wishing to make less essential conversations. Likewise, in accordance with a strict priority system, considering the situation (conditions) in the air, the landing of modern transport aircraft are controlled by an automatic landing controller.

The work of cybernetic machines is somewhat like what in human practice is called the forming of habits, professional skills, based on experience acquired earlier. But a human dispatcher must have a well-developed memory, which is one of the properties of the brain. The laws of the activity of the brain have always been the subject of study of a special science: physiology. Therefore the designers of the newest self-controlling instruments take as their model the work of the animate self-regulator of the nervous system: the brain, converting its reactions into means of modern technology.

Thus cybernetics is the offspring of physics, expecially electronics, and of the physiology of the nervous system. Mathematics must also be added to these. Cybernetic machines are first of all digital analzers, that is, differential analyzers. They are a combination of many common machines and instruments. Here there occurs something similar to automatic information by telephone; here are realized the principles of the tape recorder preserving recorded sounds, the arithmometer making a lightning calculation, television, the typewriter, electric servo-mechanisms which fulfill commands on the basis of computations. Machines like the "BESM," "Strela," "Pogoda," are equipped with instruments which help alter the speed of the solution of mathematical and logical tasks, depending on the results of operations performed earlier.

Cybernetics is confidently entering factory shops, laboratories, medical institutions. Electronic machines widely use modern automation and remote control to control machine tools, shops, and plants; to regulate the work of hydro- and thermo-electric stations without the help and intervention of man. Together with metal-lurgists, control engineers have created the first "self-servicing" and "self-controlling" automatic electric furnace. Cybernetic machines can deal with integral and differential calculus, can read aloud to the blind with the aid of a system of photoelements, and can translate scientific articles from one language into another. Translation is taken up in a special article in the current issue of this journal; from it readers may glean some information about the working principles of cybernetic machines — in this case, translation machines. Cybernetics aids weather forecasters and physicians. Electronic machines count the red and white blood corpuscles, regulate the dosage of anesthetics and oxygen during operations, read electrocardiograms, etc. We are acquainted with the use of a special electronic machine to diagnose illnesses.

Our country's victories in mastering space would be impossible without the flowering of Soviet cybernetics. Computers have helped

calculate the trajectories of Soviet earth satellites and space rockets. Electronics has made possible the communication of satellites and rockets with the earth, and the launching of an automatic interplanetary station. Electronics is also playing a decisive role in the completion and accurate aim of powerful rockets for launching heavy earth satellites and for making flights to the planets of the solar system.

The speed and accuracy of the electronic machines used in production and transportation exceed all possible human endeavor; they can perform more than 10,000 computing operations a second, and they continue to increase in capacity.

The Seven-Year Plan for the further development of the national economy of our country discloses the enormous perspectives for all branches of science and technology. In the solution of the tasks set by the XXI Congress of the CPSU and by the June Plenum of the CC CPSU in the field of technical progress, an important place belongs to electronic computing. Cybernetic machines will help solve the most varied problems of the mechanization and automatization of production.

Let us examine the other side of the question. The achievements of cybernetics evoke certain fundamental controversies. This occurs because the foreign literature more and more often is trying, prodeeding from the successes of the new applied mathematics and electronics, to consider the work of the human brain as the work sui generis of a computer serving to produce responses to a given type of "information" coming from without.

Is this assertion correct?

The central nervous system is defined by foreign cyberneticists as an instrument possessing the reactions of choice, analogously to the above-mentioned machines. Tracking systems are equated to attention, etc.

This comparison, and, sometimes, the complete identification, of the human brain with a machine clearly contradicts Darwin's evolutionary theory of the gradual development of all nature, including the brain. This tendency has its roots in the views of the 17th century philosopher Descartes regarding the essence of "animal-machines," and of Lamettrie regarding man as a machine. Some modern cyberneticists call cybernetic machines reflex machines [see Note 6].

([Note:] As we know, the term "reflex" arose with Bescartes from a comparison of the transmission of nerve excitation to the reflection of a light ray in the mirror of an optic telegraph, i.e., from a comparison with the action of a physical instrument. This comparison played its positive role in the science of the brain. The reflex concept was wodely used by I. M. Sechenov and I. P. Pavlov.)

Can we agree with this?

The attempt of cyberneticists to find general principles in all of nature, to lighten mental work, the work of the memory, attention, and many other human mental functions, by transferring them to a well-built, untiring electronic machine, should be welcomed. The new machines created by cyberneticists are in a certain sense combines of mental work. However, one must bear in mind that we are in no way referring to a

"robot era," that we do not imply that with the appearance of cybernetics the role of man in the production process has become less important. The skill of our cerebrum—the organ of social consciousness—as an analytic calcualtor, possessing, in the opinion of some cyberneticists, a slower and less perfect action than a calculator, is extremely questionable.

The difference between these biological and technical devices is not only that animals are capable of self-development (many cyberneticists admit this), but that man, possessing a developed brain, begins at a definite stage of culture to alter his' surroundings, occupying himself with socially-useful constructive labor. But electronic machines c an enter into no kind of production relationships with each other, can create no new social milieu. They form no new abstract concepts characteristic even of an adolescent, e.g., the concepts of beautiful and ugly, of good and evil.

The incorrect idea of the brain as an electronic machine is adhered to by many foreign authors: Norbert. Wiener, (the first to define cybernetics as the science of communication functioning in machines, in animal organisms, and in human society), Shannon, Couffignal, W. Walter, Ashby, et. al. They consider it possible to unite the "theory of information," the theory of computers, and the laws of higher nervous activity into one whole. This is incorrect. Biological phenomena represent a particular type of movement of matter much more complex than the movement of electrons. In the brain, as in all animate nature, there is an exchange of substances, in the process of which the very matter of the brain is created and by which its reactions are assured. But in a machine, as in other inanimate bodies, the exchange of substances leads not to the creation of new elements and properties, but th destruction. The corrosion of metals is an example.

I. P. Pvalov, the founder of the theory of conditioned reflexes, of temporary connections in the contex as the basis of higher nervous activity, long ago foresaw the possibility of such a simplified explanation of his discoveries, and struggled against superficial analogies. In one of his articles, likening the work of the centers of the cortex to the action of an automatic telephone statiion where many contacts between individual subscribers are made, I. P. Pavlov emphasized the qualitative peculiarity of neuro-cerbral communication in comparison with telephone communication, and actively struggled against the term "mechanics of the cerebrum," [see note] which many unthinkingly use very widely but which does not express the chemical and other aspects of the activity of the brain.

([Note:] "Mechanics of the Cerebrum" was the title of a popular-science film produced in 1923 (directed by Pudkovkin and Tyagay), in the making of which I. P. Pavlov refused to participate personally.)

In the study of technical instruments and physiological reactions, which also are condermed with conditioned reflexes, I. P. Pavlov demanded that their similarity not be exaggerated, that we not be satisfied with models and hypothese, even the most brilliant ones, but that we search for facts, new laws of higher nervous activity. So far science has no such unquestionable facts in favor of identifying cybernetics with the

physiology of the nervous system. Moreover, I. P. Pavlov thought that from the competition (but not from the merging!) of the two sciences — physiology and physics — physics might be the winner.

Wat are the essential differences between a cybernetic machine and the nervous system?

Pavlov's first proposition states that conditioned reflexes, temporary communications, always arise on the basis of unconditioned reflexes. An electronic machine, on the other, hand, has introduced into it earlier by the mathematician a great quantity of data — programs and subprograms — which are stored in the electronic memory (television tube, magnetic tape). Nevertheless, these programs can in no way be equated to an unconditioned reflex, which came into being over the course of millions of years and which is the basis of the instincts which regulate the biological conduct of animals. In cybernetics, in all its magnitude there arises before us the work of man: the creator of the mathematical programs and designer of the modern machines. By means of combinations of the data introduced, the machine establishes communication, solves the most complex tasks with a most astonishing speed, depending on the rate of motion of the electrons in the cathode tubes of the semiconductors. This communication and this processing of information cannot at all be compared with conditioned reflexes, since there is no creative act, no new quality, no transformation of matter to another for of matter, even if we consider that the new technology may lead to programming machines. Even these will be invented by man! Neither in the case of self-regulating machines (the homestats of Ashby and others) can we speak of the creation of an electronic brain — with or without quotation marks.

Representatives of modern foreign cybernetics forget the main thing — that the labor of man, regulated by the brain, is a purposeful activity in the process of which the tools of labor and machines are created, including mathematical machines. It never occurs to the mechanists that the work of a mathematician's brain is formed by degrees, at the highest of which is inventive and design activity.

Cyberneticists assume that their science in its modern form is able to explain to the physiologists several very complex points about the work of the brain. We cannot reject this tendency. We cannot, however, believe that all higher nervous activity is subject to happenstance, to the mathematical theory of probability, that is, to purely statistical regularity, since this is contrary to Pavlov's principle. This itself would repudiate the casual relationship of the phenomena which takes place in our brain, in our thinking, in our behavior. And this leads to the idealism and agnosticism from which the American behaviorists suffer.

Does this denial mean a break between cybernetics and physiology?

No, it does not. Physiciologists occupied with the elaboration of the Pavlovian legacy, though they do not recognize the American interpreters of cybernetics, share with the designers of the new control machines their experience in studying the complex phenomena of higher nervous activity in order to enrich technology. Many of these complex phenomena may be reproduced by our industry by the usual engineering means, casting

aside the incorrect attempts to make analogy pass for sameness. Thus the close relationship between physiology and physics dreamed of by I. P. Pavlov is fully possible and is already coming about.

Further, foreign cyberneticists, basing their ideas on the data of American idealistic physiology, taking on faith many of its conclusions, consider the notorious "all or nothing" law as fully proven. They compare the nerve cell to the cathode relay, in which there really exist only two situations: open and closed. This comparison is necessary to them in order to justify the dual system of notation, that peculiar language which is used in computers for speed in computing.

B ut the "all or nothing" law, even with respect to the nerve fiber, and even more so the cell, must be limited or even rejected, as not corresponding to the facts of the biology and physiology of the nervous system. Between the two extreme degrees (higher excitation and complete rest) is a great number of transition phases which we saw in the laboratory of I. P. Pavlov, working on the higher nervous activity, on the process of establishing and extinguishing reflexes.

One of the bases of the philosophic, and not only the terminological, misunderstandings in this dispute of principles is the cyberneticist-mechanists' lack of understanding of the difference between reflexes of the first and second signal system in the sense given to this by I. P. Pavlov. We recall that the second system, characteristic only of man, is shown by the ability to generalize and abstract broadly. This generalization and abstraction takes physiologically entirely different routes than in the first(indirect) system of the brain, although the reflexes of both systems are the products of the same nerve fabric. If the work of the first signal system realizes the indirect communication with reality, then the second signal system—and only the second—, serves thought in abstract concepts and uses words and formulas. In the case of mathematics the second signal system creates the theory of non-Euclidian geometries which do not stem indirectly from daily experience.

It is just this point, this possibility of introducing into a machine the ability to abstract, that the designers of these "thinking," control, reading, and translating machines are laboring. They want to prove that the development of the "thinking" of these machines is unlimited. But suffice it to recall that speech, spoken intercourse, characteristic of man, embraces the phenomena of the world more broadly than a computation of objects done by a machine, although the counting operations are accomplished with lightning speed.

When we speak of a "table" we, with the help of the second signal system, embrace not <u>all</u> tables which have ever existed, and will exist, the objects of all historical epochs, all countries, in which people have lived and do live. This is "table" in general. Finally, imaginary objects of this sort, still not existing in nature, also are the field of the second signal system. A machine cannot accomplish such broad foreseeing, although it can count any phenomena, each having its definite algorism, that is, the strict rules and order of solution of tasks. Concepts of "morality," "technical progress," to say nothing of the dialectical movement of abstract ideas, especially the philosophical difference between necessity and chance, etc., can of course not be

worked out by any self-regulating machines or homeostats.

What should be the further development of the union of the sciences of animate and inanimate nature, which have become related, the isolation of each from the other having been surmounted?

O course, in the presence of the indispensable participation and activity of both sides — the mathematicians and the physiologists, people pretty often forget them, incorrectly assuming that the theories of Pavlov have said all thebe is to say. Physiologists and physicians, for their part, must acquaint themselves in greater detail with the work of electronic machines, in order to adapt them to the purposes of laboratory and clinical practice. Cybernetics may become a miraculous assistant to the physician in determining diagnoses. But undoubtedly not even the most ideal machine can replace the clinical thinking of the physician at the sickbed of the patient. Every man is a unique individual; the process of healing a sick person cannot be mechanized and standarized.

We can imitate, or as they say, program, the work of the hands of the best surgeon, studying and transfering to an electronic device all his work, for examply, an appendectomy. Nevertheless, the operation itself cannot be entrusted to the most perfect cybernetic machine: there are as many varieties of this surgical illness as there are prople.

Thus the new universal and special computers, those coming intp being to a certain degree replacing not only eyes and ears but also touch and equipped with analyzers for sorting out and generalizing the information perceived by their "sense organs" can never fully replace the work of the brain or all the work of man. A study in depth of the newest stage in the development of automation and cybernetics shows that the substitution of a machine for amn does not threaten us. In the future cybernetics will lighten more and more the mental work of millions of people, the fulfillment of creative and production plans; but it will never be able to replace the higher creative activity of inventors and scientists, can never create a revolution in social life. Automatic machine control will never supplant the dearest thing in our society — the initiative of the workers and collectives of workers which by their experience and enthusiasm advance the economy and science itself.

5190

— END —